The Texas Basins Project[1]

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ABSTRACT

The Texas Basins project is part of a plan to develop water resources of Texas to meet projected municipal, industrial, and insofar as possible, irrigation requirements in the year 2010. Eighteen reservoirs would supply water to a trans-Texas canal which would intercept tributary discharge to all coastal marshes. The large anticipated demands not related directly to the project, combined with project diversions, would reduce by one-half the average annual freshwater flow of 26½ million acre-feet now reaching Texas estuaries. The reduction could exceed 75 percent during dry years. The Texas Basins project would account for about one-third of this reduction.

About 1⅓ million acres of tidewater in Texas yield about 200 million pounds of fish and shellfish annually to commercial fishermen, and support more than 7 million man-days of sport fishing. Expected expansion of commercial and sport fisheries will be restricted if the amount of fresh water reaching the coast is reduced permanently and significantly. Reduction of tributary discharge attributable to the project, and the introduction of toxic pesticides into two estuaries from adjacent irrigation units, could cause annual losses of an estimated 118 million pounds of commercial fishery products, and nearly 3 million man-days of sport fishing.

Losses could be prevented and certain benefits realized by enlarging the scope of the Texas Basins project to provide for maintenance of estuarine fishery resources, and to prevent the discharge of toxic pesticides.

INTRODUCTION

The proposed Texas Basins project is an integral and significant part of a statewide distribution system that would provide water to meet anticipated municipal and industrial requirements in the year 2010. It would also permit development of more irrigable lands. The overall plan is essentially the one adopted by the U. S. Study Commission for Texas in 1962.

The population of Texas is expected to grow from 9.6 million people in 1960 to nearly 23 million in 2010. Accordingly, municipal and industrial water needs during this period will increase from 1.7 million to over 12 million acre-feet per year. About 105 small and intermediate-size reservoirs supplied water in 1960. It is now estimated that to meet the water demands of 2010 an additional 70 major reservoirs will be required, together with a transport system to deliver the water where and when needed. The Texas Basins project would supply about one-eighth of the projected requirements for municipal and industrial use, plus enough water to develop 785 thousand acres of new irrigated farmland. It would also afford a nominal amount of flood control and provide some recreational benefits. In its development additional consideration would be given other purposes such as navigation, power, improvement of water quality, and fish and wildlife.

Information on municipal, industrial, and agricultural water requirements, and on details of the Texas Basins project was obtained from unpublished reports and records of the U. S. Bureau of Reclamation and the Fish and Wildlife Service, although much of the descriptive material contained herein has been released to various news media in condensed form. An example of many such releases is that by Pyle (1963) who, like others in similar circumstances, gave little attention to the probable effects of such projects upon coastal fish and wildlife resources. In all fairness to such reporters, however, they are usually not made fully aware of what is at stake for these natural resources. Conservationists must therefore improve their channels of communication.

Fortunately, the Congress of the United States has recognized the importance and value of fish and wildlife resources, in addition to the need to plan and coordinate properly all Federal as well as privately sponsored water development projects involving the country's navigable waters. Legislation enacted in 1946 charges the U. S. Fish

[1] Contribution No. 206, Bureau of Commercial Fisheries Biological Laboratory, Galveston, Tex.

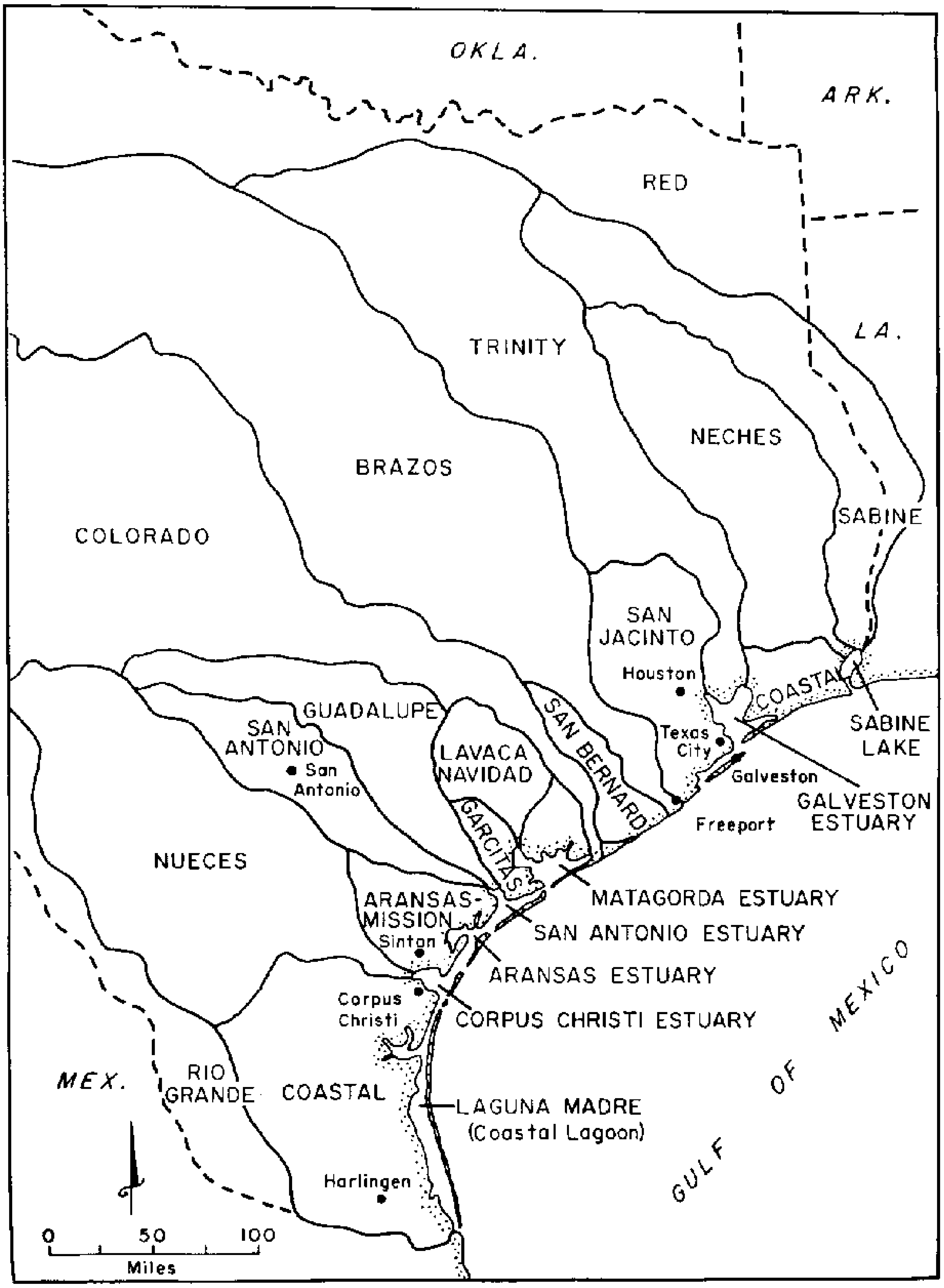

FIGURE 1.—Major river basins and estuaries in Texas.

and Wildlife Service with the responsibility of protecting the public's interest in the fish and wildlife resources so affected. Thus, under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) the Service, in cooperation with appropriate state conservation agencies, reviews these projects to evaluate their potential effects and, if necessary, to recommend changes that will benefit or will minimize anticipated damage to these valuable living resources.

The Fish and Wildlife Service has a tremendous task in discharging its responsibility under the Coordination Act. Literally thousands of water development projects are in the planning stage, have been authorized, or are under construction. They vary in scope from small single-purpose efforts such as the construction of wharves or piers, to large navigation channels and multi-purpose projects which involve the water resources of an entire river basin or, in the case of the Texas Basins project, a series of river basins. The potential effects of such an array of diversified activities upon coastal fish and wildlife resources are as varied and complex as the projects themselves (Diener, 1965; Kutkuhn,

TABLE 1.—*Texas estuaries and their major subdivisions*

Estuary	Major components	Tributary rivers	Area in surface acres
Sabine Lake	Sabine Lake	Sabine, Neches	45,000
Galveston	Galveston Bay East Bay Trinity Bay West Bay	Trinity, San Jacinto	336,000
Matagorda	Matagorda Bay Lavaca Bay	Lavaca (with Navidad)	233,000
San Antonio	San Antonio Bay Espiritu Santo Bay Mesquite Bay	Guadalupe (with San Antonio)	138,000
Aransas	Aransas Bay Copano Bay Redfish Bay Mission Bay	Mission, Aransas	127,000
Corpus Christi	Corpus Christi Bay Nueces Bay	Nueces	116,000
Laguna Madre[1]	Upper Laguna Baffin Bay Lower Laguna	—	317,000
TOTAL			1,312,000

[1] Hypersaline coastal lagoon; not a true estuary.
Source: Navigation charts prepared by the U. S. Coast and Geodetic Survey.

1965). The one project, however, which promises to affect most adversely the fish and wildlife resources in the Gulf Coast area is the Texas Basins project. The Fish and Wildlife Service therefore has assessed its probable effects and attempted to find solutions to the problems it poses (U. S. Fish and Wildlife Service, 1963, 1964a, 1965).

All tributary discharge and return-flow data employed herein were obtained from records of the U. S. Bureau of Reclamation (unpublished). Fishery statistics were extracted from U. S. Fish and Wildlife Service publications as follows: "Fishery Statistics of the United States" (by years, 1950–61); "Gulf Coast Shrimp Catch by Area and Depth" (by months, January 1956–December 1962); "Texas Landings" (by months, January 1950–December 1962); and "Shrimp Landings" (by months, January 1956–December 1962).

DESCRIPTION OF THE PROJECT

Area of Influence

The structural features of the Texas Basins project would be located in the Gulf Coast region of Texas and in the inland portions of the Sabine, Neches, Colorado, Guadalupe, San Antonio, and Neuces River Basins (Figure 1). The area influenced by the project would include about two-thirds of the state, and particularly its major coastal bays and lagoons. From east to west these coastal waters are Sabine Lake, the Galveston, Matagorda, San Antonio, Aransas, and Corpus Christi estuarine systems, and the hypersaline Laguna Madre (Figure 1). The combined areas of the estuaries and coastal lagoons exceed 1.3 million surface acres (Table 1).

Plan of Development

Project features are divided into two groups. Group I includes the interbasin canal, seven major reservoirs, three reregulating reservoirs (for irrigation), and three irrigation units containing 750 thousand acres. Group II features include 11 major reservoirs and 3 smaller irrigation units totaling 35 thousand acres. Group I facilities would be supplemented by five nonproject reservoirs (Figure 2).

The key element of the proposed Texas Basins project is the interbasin canal which would be a man-made river paralleling the Gulf Coast for 418 miles from the Sabine River to the lower Rio Grande Valley. Its capacity would vary between 2,000 and 5,900 cfs. Structures on the canal would include nine large pumping plants and nine large siphons at stream crossings. Three project reservoirs: Confluence, Sabine Diversion, and Voth; and two nonproject reservoirs, Wallisville and Palmetto Bend, would facilitate transection of major streams. The other Group I reservoirs, Goliad, Liberty, Ponta, and Teneha, would be located inland from, but provide waters for diversion by, the interbasin canal. The Group I irrigation units—Sinton, Baffin Bay, and Lower Rio Grande Valley—would be situated near the cities of Sinton, Corpus Christi, and Harlingen, respectively. A reregulating reservior is planned for each of the three units.

Stages of Construction

Construction of the Texas Basins project would take several decades. Group I facilities would be erected first in several stages. The interbasin canal and the Confluence, Sabine

TABLE 2.—*Estimated schedule of development for major features of the Texas Basins project*

Project and supplemental features	Number	Construction schedule or status
Project—Group I		
Interbasin canal	1	10 years
Major reservoirs	7	Within 10–30 years
Reregulating reservoirs	3	Within 10–30 years
Irrigation units	3	Within 10–30 years
Project—Group II		
Major reservoirs	11	As required but probably after 30 years
Irrigation units	3	Not until reservoirs constructed
Nonproject—Supplemental		
Major reservoirs	5	Underway, authorized, or being recommended

Source: Unpublished reports of the U. S. Bureau of Reclamation and Fish and Wildlife Service.

constructed to meet increasing requirements. Authorization for construction of Group II reservoirs will probably be sought individually as the need arises. Table 2 summarizes the estimated construction schedules for major components of the two groups.

Operation

The interbasin canal would intercept and divert stream flow that would otherwise enter Texas estuaries. It would deliver water to communities and cities along the entire Texas coast and supply water to the newly created irrigation units. To accomplish this, the canal would connect basins of major Texas rivers and create a single water supply system for the entire project area.

Tributary Discharge

Historically (1941–57), Texas estuaries have collectively received an average of 26½ million (range 6 to 52) acre-feet of fresh water per year from upland sources.[2] One should readily appreciate that this water is not distributed equally among the various estuaries, the State's easternmost bays and marshes receiving much greater amounts than those in the semiarid southwest. The decline in tributary discharge from east to west is evident not only for average runoff conditions but for years of high and low discharge as well.

The U. S. Bureau of Reclamation has estimated that 52 planned, nonproject reservoirs would reduce average tributary flow entering the estuaries to 18 million acre-feet per year. Project diversions would further decrease the flow so that on the average only 14 million acre-feet would be received annually. During very dry years total discharge (not including return flows) would probably not exceed 1½ million acre-feet, a level so low that it could be expected to have serious consequences. In view of the amount of tributary water received historically by each of the estuaries, the greatest losses based on percentage reduction would occur in the State's central and westernmost estuaries where supplies are even now frequently deficient. Estimated changes from the historic tributary discharge into each estuary are shown in Figure 3.

Return Flows

As tributary discharge to the estuaries declines, return flows, i.e., water diverted from the tributaries, used, and returned as sewage or industrial and agricultural waste, would increase. Thus, in future dry years slightly over one-half (2⅓ of 4 million acre-feet) of the tributary water destined for Texas estuaries is expected to be in this form. We can only speculate as to its probable quality. Hopefully, improved treatment measures and enforcement of pollution-control legislation will permit at least some of the return flow to substitute for unused tributary discharge.

FISHERY RESOURCES

A significant portion of the United States commercial fishing industry is located in the Gulf of Mexico region. From 1950 to 1963, the relative contribution of Gulf landings to the total United States commercial fishery harvest rose from 12 to 29 percent (U. S. Fish and Wildlife Service, 1964a). It follows that the commercial fishing industry of Texas is likewise growing (Figure 4). In recent years, the value of its annual production, which now averages about 200 million pounds of fish and shellfish, has usually exceeded that of other Gulf Coast states, mainly because of large harvests of the valuable brown shrimp, *Penaeus aztecus.*

[2] Excludes the Colorado River which formerly emptied entirely into Matagorda estuary but now discharges an undetermined amount of water directly into the Gulf of Mexico.

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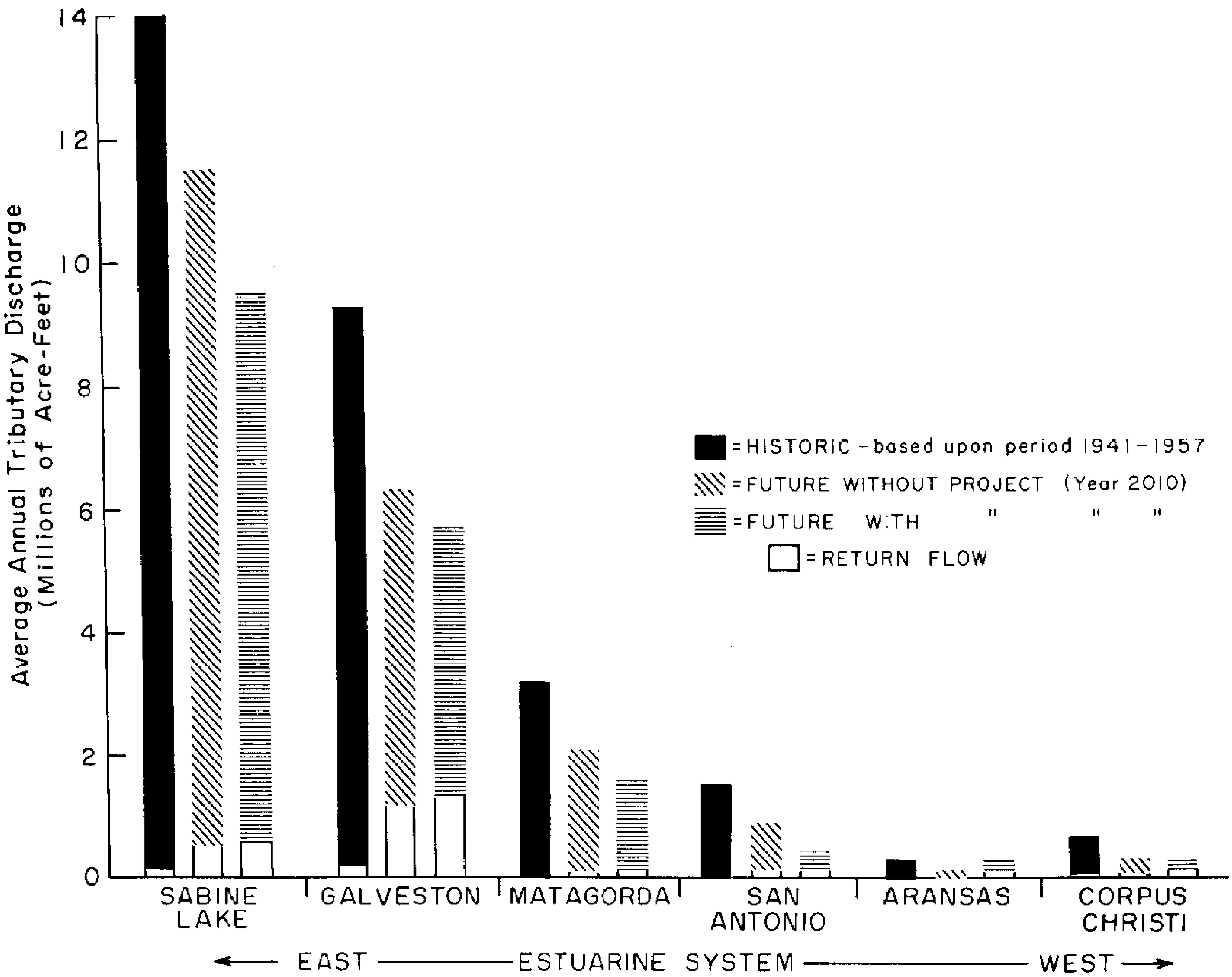

FIGURE 3.—Estimated future change in tributary contributions to Texas estuaries.

Significantly, about 98 percent (by weight) of Texas landings consists of estuary-dependent species (U. S. Fish and Wildlife Service, 1964b). These include both resident and semicatadromous forms. Resident forms are exemplified by the oyster, *Crassostrea virginica*, which completes its life cycle entirely within the estuary. Semicatadromous species include the brown shrimp, *Penaeus aztecus*; white shrimp, *P. setiferus*; largescale menhaden, *Brevoortia patronus*; Atlantic croaker, *Micropogon undulatus*; striped mullet, *Mugil cephalus*; spot, *Leiostomus xanthurus*; sand seatrout, *Cynoscion arenarius*; and red drum, *Sciaenops ocellata*. These species spawn in the Gulf of Mexico, but the young move into the estuary where they grow rapidly to subadults before returning to the Gulf where their life cycle is completed. Other important estuarine-marine species include the blue crab, *Callinectes sapidus*, and the spotted seatrout, *Cynoscion nebulosus*, both of which normally spend most of their lives within the estuary. Fairly large stocks of all of the aforementioned species now exist, but, with the possible exception of the oyster and brown and white shrimps, have been only partially exploited. If suitable environmental conditions in the estuary can be maintained, it is not unreasonable to expect that their overall harvest will more than double over the next three or four decades.

In addition, the U. S. Fish and Wildlife Service (unpublished) has estimated that Texas estuaries annually support more than 7 million man-days of sport fishing for estuary-dependent species. Recreational fishing is also expected to increase significantly as the human population expands. By 2010 the estuaries may be called upon to provide about 17 million man-days of angling.

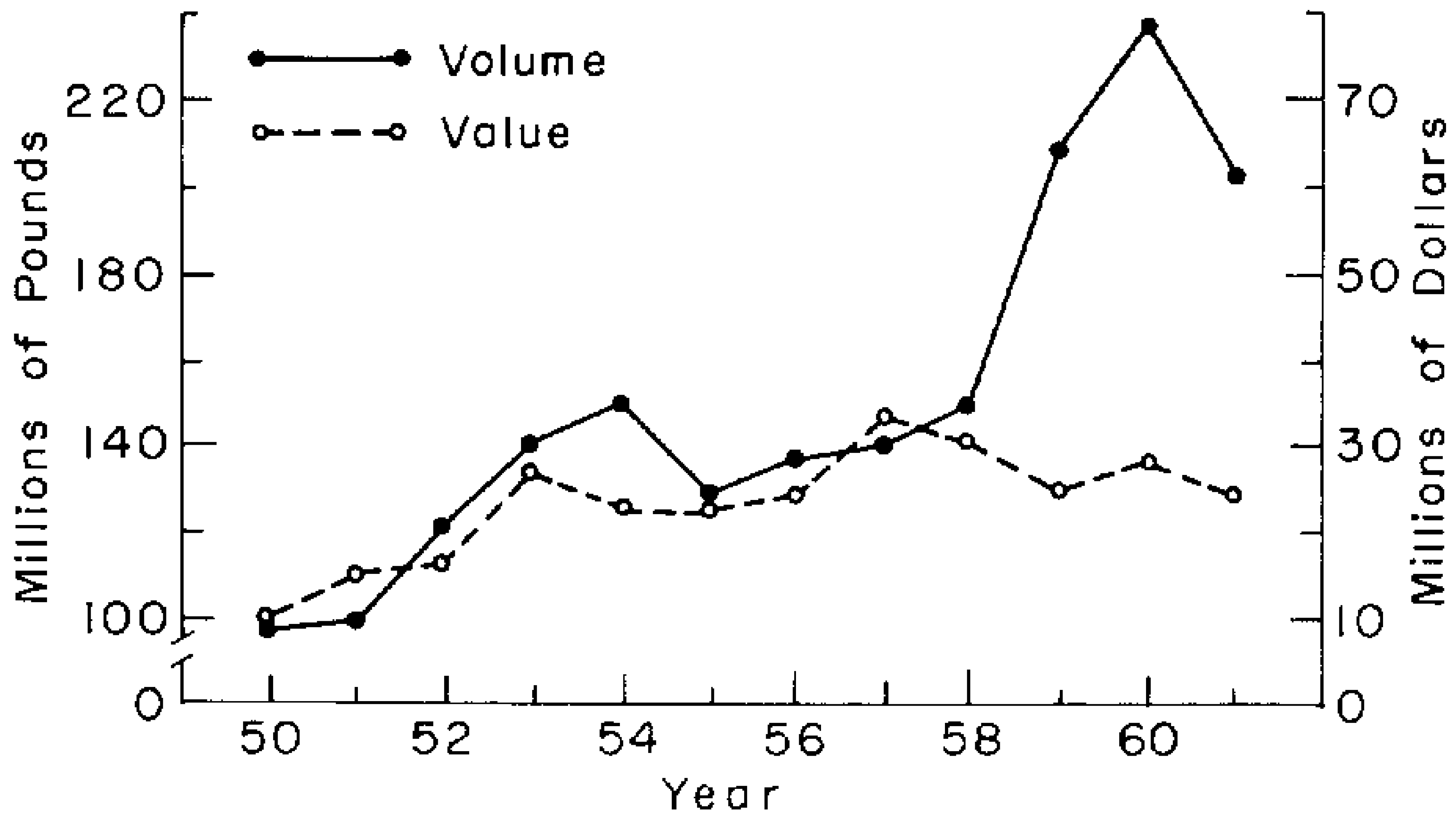

FIGURE 4.—Commercial fishery landings in Texas, 1950–1961.

TRIBUTARY DISCHARGE AND FISHERY HARVEST

Since about 90 percent of the harvest of estuary-dependent fishery resources from Texas coastal waters occurs in the Gulf of Mexico after the various species leave the estuaries, catch statistics alone do not directly indicate the relative importance of individual bay systems in maintaining such resources. It was necessary therefore to develop some means of relating harvests in the Gulf to the particular estuary in which the young of the species involved (chiefly menhaden, and white and brown shrimp) were most likely nutured. Particularly useful in this regard were the facts that harvest areas in the Gulf are accurately known, that white and brown shrimp tend to move southwestwardly along the coast after leaving the estuaries, and that the relative abundance of juvenile shrimp in each estuary has been assessed regularly since 1960 by the Texas Parks and Wildlife Department (unpublished). To apportion the Gulf catch on the basis of estuarine origin, it was therefore assumed that individual bay systems contributed white and brown shrimp to harvests from the adjacent Gulf, and from those waters immediately to the west, in direct proportion to the size of the juvenile populations they harbored. It was also assumed that since menhaden are now taken solely off eastern Texas, only those utilizing the State's easternmost estuaries contribute to Texas landings of this species.

Estuaries in eastern Texas, which receive the greatest amount of tributary discharge in relation to their volume, are believed to contribute more to the well-being of fishery resources harvested commercially in Texas waters than do those lying to the west. As an example, the Galveston estuary, with a high discharge-volume ratio, yields on the average (by weight) about 30 times more commercial fishery products per unit area than does Laguna Madre, which has approximately the same surface area. Generally, the discharge-volume ratio is highest for the easternmost estuaries, declines appreciably in the central estuaries, and reaches its lowest level in the extreme southwest. Harvests of their fishery resources follow a similar pattern although wide variation is evident between individual estuaries (Figure 5).

It is also apparent that the influence of tributary inflow upon estuarine fishery resources varies considerably between estuaries because of differences in basin size and configuration, and in the quantity and quality of fresh water received. For example, the Aransas estuarine system receives less runoff than the San Antonio estuary but yields a greater harvest. Both Copano and Mission bays, in Aransas estuary, are shallow and restricted at their lower ends so that small amounts of tributary runoff measurably affect their suitability as (estuarine) habitat for many species over relatively long periods. Espiritu Santo

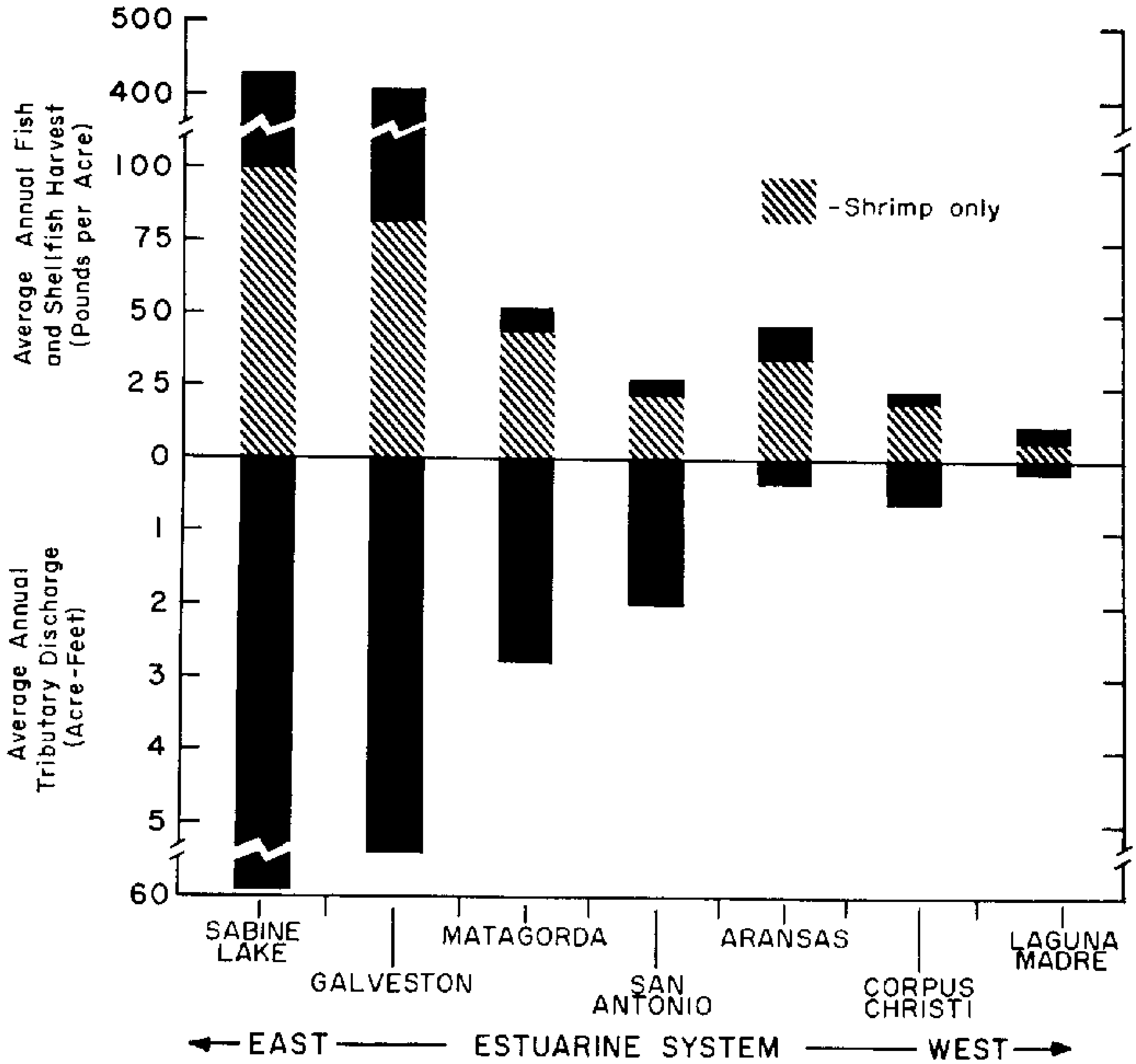

FIGURE 5.—Commercial fishery harvest in relation to amount of fresh water received by Texas estuaries. Tributary discharge has been adjusted for volume of estuarine basin by dividing basin volume by discharge volume. (Period of analysis: 1956–62.)

Bay of the San Antonio estuary, on the other hand, does not receive tributary fresh water directly and its waters are therefore almost as saline as the nearby Gulf. Also, the salinity of San Antonio Bay proper is subject to extreme and rapid fluctuation because of the peculiar pattern of tributary discharge. Thus, each estuary has many unique characteristics that must be considered when assessing the freshwater requirements of the fishery resources inhabiting it.

Even though the trend in commercial fishery production has been upward in recent years, considerable variation in harvest is evident from year to year and between so-called wet and dry cycles. Fishery harvests during a series of wet years are generally greater than those realized in dry years (Figure 6). Excessive tributary discharge into a specific estuary, however, can probably be detrimental if the resulting "freshwater" conditions prevail for long periods. Use of the estuary would then be temporarily restricted to freshwater forms or to those estuary-dependent animals such as the white shrimp or blue crab which can apparently withstand such conditions.

Greatly diminished brackishness often characterizes Sabine Lake in the eastern part of the State but rarely occurs in the central and westernmost estuaries. Conversely, projected reduction in tributary discharge could, in effect, permanently duplicate adverse hydrological conditions that accompany temporary but severe droughts. Thus, abnormally high salinity could be expected in all estuaries except Sabine Lake. Even hypersalinity, as now typifies Laguna Madre, might be expected periodically in those estuaries located along the central and western portions of the coast.

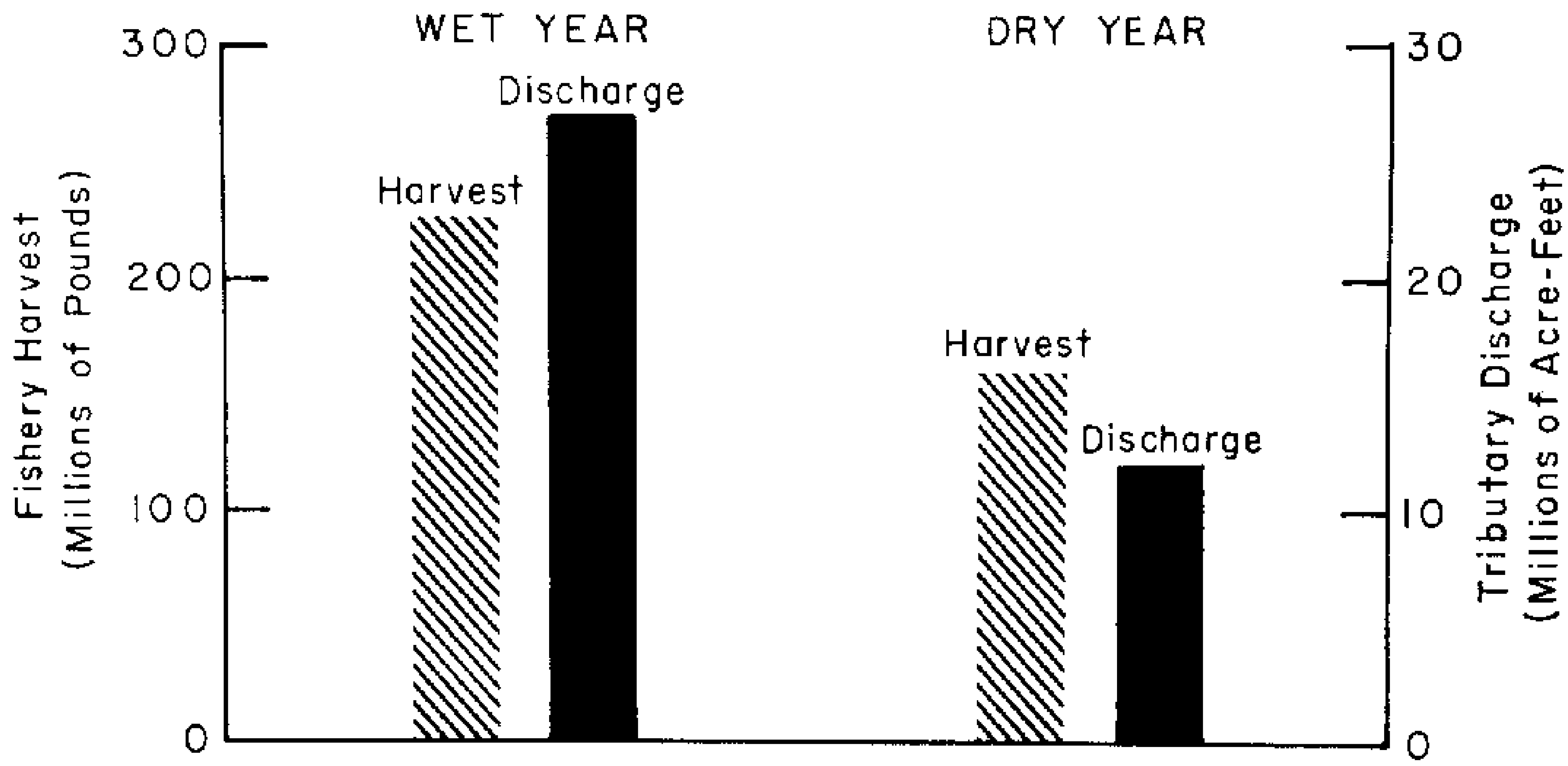

FIGURE 6.—Commercial harvest of estuary-dependent fishery resources from Texas waters during wet and dry years. (Period of analysis: 1956–62.)

Lower yields of fishery resources, which are believed to often reflect such adverse conditions, would then result. However, since losses of tributary discharge would occur slowly as the project develops over a long period the commercial fisheries involved could be expected to continue expanding for many years but thereafter steadily decline.

Since both project and nonproject structures would gradually and permanently lessen tributary discharge into Texas estuaries (Figure 3), we have assumed for purposes of preliminary evaluation that the subsequent effect upon estuarine fishery resources would be in direct proportion to the amount of water diverted. Even if the Texas Basins project should never be built, significant reductions in tributary discharge due to other diversion projects would still appreciably curtail the potential of both commercial and sport fisheries. So the combined effects of all nonproject diversions were determined first to provide a basis ("future without-the-project") upon which the added effects of the Texas Basins project could be evaluated.

Prediction of future fishery harvests with and without the project were based on historic harvest records of fish and shellfish utilizing each estuary for a year during which tributary discharge was at a level comparable to the average discharge expected in the future. Since future flows will decline, the records used to estimate future harvests invariably were those associated with periods of drought. Historically, droughts were relatively short in contrast to the severe, semipermanent drought-like conditions expected in the future. Nonetheless, historic records offer the best basis at this time from which to prejudge the effects of depleted tributary flows into the estuaries.

We have estimated that in the 100-year period over which economics of the State's water-resource development program without the Texas Basins project have been analyzed (about 1966–2065), commercial fishery harvests would average about 330 million pounds a year, roughly 150 million pounds below their potential. Under similar conditions the estuaries would support an estimated 14 million man-days of sport fishing, a loss of 3 million.

Tributary discharge would be reduced still more by project diversions. Furthermore, the project would also contribute in return flows to Aransas and Corpus Christi estuaries from adjacent irrigation units, large amounts of toxic pesticides and herbicides, which are known to be harmful to fishery resources (Butler and Springer, 1963). Severe pesticide contamination could virtually eliminate the commercial fishery resources that utilize these bay systems. We have estimated that reduction of tributary discharge attributable to the project, together with the introduction of toxic pesticides, could therefore inflict average losses over the 100-year period of analysis of about 118 million pounds annually to the commercial fishery harvest, and nearly 3 million man-days of estuarine sport fishing.

NEED FOR FURTHER RESEARCH

Combined project and nonproject losses to estuarine fishery resources could be catastrophic to the future of the commercial fishing industry of Texas.

It must be realized, however, that the projections given here are subject to modification. Changes in tributary discharge are predicted upon large increases in population together with attendant industrial and agricultural expansion. Similarly, our estimates of the effects of future changes in tributary discharge upon commercial fishery harvest are based on short-term records. Considerably more research and study will be required before we can predict with reasonable confidence the specific effects of such changes. Even with the limited data available, however, it is obvious that estuarine fishery resources in Texas will face a major problem.

In recognizing the problem and attempting to do something about it, the first big step has been taken toward a solution. Because we acknowledge that the data and information available to us have severe limitations, we have recommended that additional study, as a project responsibility, be undertaken in each of the Texas estuaries to supplement and complement existing research programs. Already, the construction agency is re-evaluating fish and wildlife requirements for the purpose of determining if more project water can be supplied from the larger tributaries so as not to divert excessive amounts from the State's central and westernmost estuaries. Also being considered is the feasibility of developing additional supplies for the estuaries to replace nonproject diversions. And. with proper planning, we further anticipate that the adverse effects often associated with the introduction of toxic pesticides can be completely eliminated.

It is noteworthy, too, that a considerable quantity of water will be developed by the project but not needed until full operation is achieved. Additional supplies could also be developed by advancing the schedule for reservoir construction. Perhaps such "surplus supplies" can be made available to the estuaries to maintain their normal salt balance. Consequently, if the Texas Basins project is expanded to include fish and wildlife resource development as a project purpose, it is entirely possible that freshwater requirements for estuarine fishery resources in Texas can be met for many decades to come.

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